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TWO EPIDEMICS OF POTATO BLIGHT AND ROT.

W. J. Morse

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BULLETIN No. 169.

TWO RECENT EPIDEMICS OF LATE BLIGHT AND ROT OF POTATOES IN AROOSTOOK COUNTY.

W. J. Morse.

The summer and fall of 1907 and that of 1909 presented ideal weather conditions for the development of late blight and rot of potatoes in Aroostook county and some other parts of Maine. As a direct result of these weather conditions and the consequent development of the blight, by very conservative estimate, the loss in diminished or damaged crops in each of these years amounted to several hundred thousand dollars. Much of this loss occurred on fields where the owners were attempting to spray with bordeaux mixture, and in many cases felt that they were spraying carefully and thoroughly.

During the season of 1907 the writer was engaged in carrying on spraying experiments in Houlton and in Foxcroft, both to test the relative efficiency of thorough spraying as compared with that usually practiced by most growers, and to test the relative efficiency of certain substitutes for standard bordeaux mixture. No such experiment was conducted in 1909 but during both seasons the conditions in various parts of the State were closely observed and carefully followed up as soon as weather conditions indicated that an outbreak was imminent. Repeated visits were made to the various potato growing sections, particularly where blight was appearing and careful notes were made of spraying operations and the resulting successes or failures therefrom.

The results secured from the experiments of 1907 and the field observations during the two seasons of severe epidemic blight and rot, taken in connection with results previously obtained by Director Woods of this Station under similar con-

ditions,* and at other experiment stations, particularly those obtained at the Vermont and the New York State Station lead to but one conclusion, namely: *that from 75 to 95 per cent of the loss from blight and rot even under the severe weather conditions experienced during the two growing seasons under consideration is unnecessary and unwarranted.* In fact there are few plant diseases which are so completely and thoroughly controlled by bordeaux mixture as the late blight of potatoes and the resulting decay of the tuber caused by the same fungus.

Granted that the above statement is true, why has there been an apparent almost universal failure from spraying during the season of 1909, and to a somewhat similar extent in 1907, instead of universal success? There are several factors responsible for this condition of affairs, some of which it is proposed to discuss in some detail. The general lack of knowledge of the nature of the fungus causing the disease and its method of distribution, the intimate relation of the development of the disease to weather conditions, improperly made bordeaux mixture, inefficient or improperly constructed spraying machinery, resulting in imperfectly covering the foliage, too few applications, or if the number of sprayings are sufficient, applied at the wrong time, digging and storing too early if blight gains a foothold on the foliage.

RELATION OF FUNGUS TO PLANT AND SPRAY TO FUNGUS.

The late blight of potatoes is caused by a parasitic fungus, a low form of plant life, which is made up of minute, almost colorless threads which permeate the tissues of the healthy leaf, killing the living cells of which the leaf is made and drawing its nourishment therefrom. In the summer when once established on a few leaves in a field it spreads very rapidly, if weather conditions are right, by means of little reproductive bodies called spores, which every blighting leaf produces by thousands, if not millions.

Certain soluble copper compounds in exceedingly minute quantities are almost immediately fatal to these little spores as soon as solutions containing such copper salts touches them. The efficiency of bordeaux mixture as a fungicide depends upon

* Me. Agric. Expt. Sta. Bul. 73 (1901) and Bul. 87 (1902).

the copper sulphate or blue vitriol used in its preparation. The lime when added makes a very finely divided, but temporarily insoluble compound suspended in water which we call bordeaux mixture. The lime forms with the copper salt, compounds which slowly become soluble and makes an adhesive mixture, when dry, which slowly gives up the copper—fast enough to kill the fungus spores but not fast enough to damage the potato leaves. A very weak solution of copper sulphate would have the same effect but it would have to be applied daily in rainy weather. Spraying then serves a two-fold purpose, primarily to cover the entire healthy leaf with a thin protective film of bordeaux mixture which is constantly giving up minute quantities of soluble copper salts which kill all blight spores which find lodgment thereon before they can germinate and enter the leaf, and secondly if the blight is already started the spray may at the time of application kill many millions of spores which are ripe and ready for distribution.

The relation of the fungus to the disease is better understood by reference to Fig. 15, page 169. At the left is seen a section of an infected potato leaf, highly magnified. It will be seen that the leaf is made up of many irregularly shaped units or cells. Those above and below being flattened and forming a protective layer. In the lower layer certain lip-shaped openings are seen. These are the breathing pores or stomata through which the fungus most easily enters the leaf. It is possible, however, for the germ tube of the fungus to penetrate directly through the cell wall as shown in the illustration. Running between the cells of the leaf may be seen the threads of the fungus. In the drawing these fungus threads, though naturally nearly colorless, have been colored to make them stand out more distinctly. Projecting downward from the underside are two different appearing bodies. The tapering, pointed ones are natural leaf-hairs. The others, thread-like and branched and bearing the knob-like bodies, are the fruiting organs of the fungus, each little knob being a spore. The top row at the right shows the stages in the development of a spore. After the spore is formed it may divide up into from 6 to 16 little swarm spores, each provided with two little hair like processes by which it is enabled to swim around in drops or films of rain or dew. Later these lose their swimming organs and begin to throw out a germ

tube. If the swarm spore is lodged upon a potato leaf the tube usually enters the leaf through the breathing pores, branches and permeates the tissues, killing them as it goes. Thus it produces the characteristic blotches on the leaves as shown by Fig. 16, page 171. The spores may be washed down into the soil also and infect the tubers in the soil, or if the crop is dug while the tops are still partly green, but blighting badly, the tubers may become infected at this time and the rot develop in storage as in the season of 1909.

The remaining illustrations of Fig. 15, page 169, show the stages in the formation of swarm spores and how they finally germinate and enter the leaf. After a small dead area is produced the fungus throws out the fruiting organs as illustrated on the large section of the leaf and the process already described is repeated over again. This makes plain why it is absolutely necessary to cover each and every potato leaflet with a thorough protective coating of bordeaux mixture, and why spraying partially or improperly done may be practically useless.

When potatoes are blighting badly, if the margins of blighting spots are examined on the under sides of the leaves a delicate white fringe may be seen. (See Fig. 16.) This is made up of hundreds of little fruiting organs each bearing from one to several fruiting bodies, each of which will divide into from 6 to 16, usually about 10, swarm spores and *each of these swarm spores capable, under proper conditions, of producing another blighting leaf or capable of causing the destruction of a merchantable tuber.* It is thus easily seen how that one blighting leaf may produce sufficient spores to infect every hill of potatoes on an acre of land, provided all the spores produced could come in contact with these plants. This explains why a field, apparently free from blight, may be found to be badly affected only a few days later, and how potatoes showing a comparatively small amount of blight on the foliage before being killed by frost or before being dug, may develop a large amount of rot in the field or in storage as the case may be. In the first instance the blight existed for some days on the lower and more shaded leaves (where it would not be noticed by the ordinary observer) till a day or two of favorable weather occurred. Then a large crop of spores were produced which infected the plants on the whole field. In the case of tuber

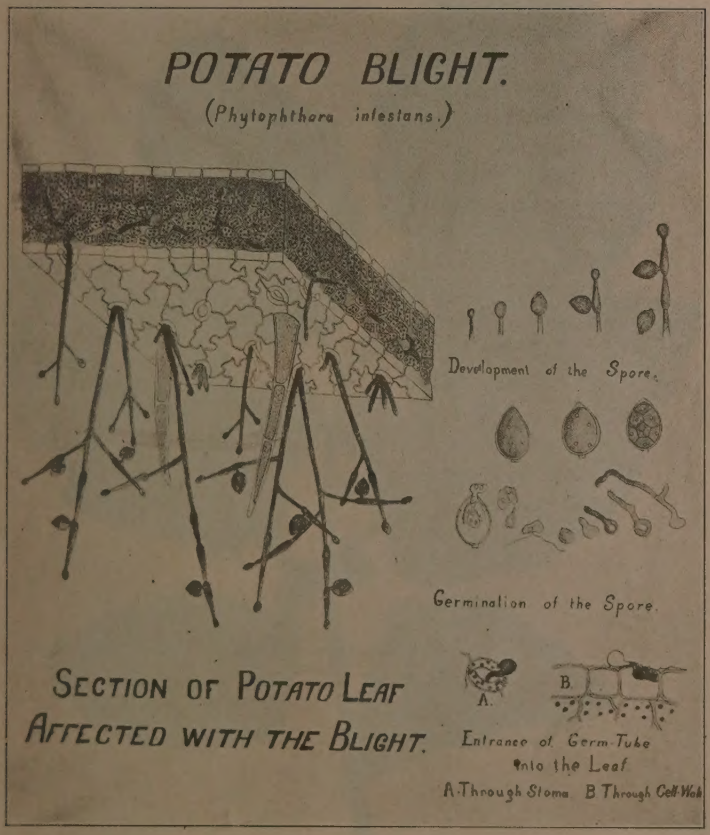

FIG. 15. From drawings by De Bary, Ward and Jones. The fungus threads and spores, though nearly colorless, are colored in the drawing to make them stand out more distinctly.

FIG. 16. Potato leaf attacked by late blight, as shown by the darkened areas on the leaflets. One of the large leaflets on the right is turned bottom up to show the delicate fringe of spore producing organs.

infection the blight may be well started on the leaves and a heavy rain wash the spores down onto the tubers in the soil, and decay at once starts up, or if the tops are producing an abundance of spores when the crop is dug, the weather cloudy or rainy, the atmosphere humid, and the tubers after being showered with millions of spores from the blighting leaves are at once picked up and stored in large bins without being allowed to dry off infection is almost sure to result as in the fall of 1909.

WEATHER CONDITIONS AND THE DISEASE.

Rain, dew, wind and insects are the chief agencies for distributing the disease. So far as known the only way that the crop of any one year is first infected is from planting diseased tubers in which the fungus has remained semi-dormant over the winter. Hence the first blow to be struck in the fight against this disease is to plant nothing but healthy, sound tubers.

Late blight revels in moist, cloudy weather and, contrary to the general notion, in relatively cool or moderate temperatures.* The spores are produced in greatest abundance in rainy or cloudy weather and are extremely susceptible to drying and hence one need never fear an outbreak in dry, hot, sunshiny weather. Wet weather is almost sure to bring it on unless spraying is kept up during the continuance of such weather. In fact there is no other disease of our common field or garden crops where a careful observer can predict with more accuracy its probable appearance or absence. From a financial standpoint this is a point that no progressive potato grower should overlook. While spraying operations should not be delayed till favorable conditions for blight appear, how thoroughly they are followed up may well be governed by weather conditions if one thoroughly understands the significance of the latter. In this latitude late blight seldom occurs to any extent before the last of July, hence the main fight against it must be conducted throughout August and September, *even up to the very day the crop is dug or the plants are killed by frost.* As will

* "Humid, still days, with a temperature of about 73° F. Above 78° F. and below 50° F. there is practically no germination of the spores." Fraser, Samuel, The Potato, p. 114, Orange Judd Co., N. Y. (1908).

be seen later this latter recommendation is not in accordance with the most common practice where spraying operations are suspended much too early in the season.

PROPERLY MADE BORDEAUX ESSENTIAL.

In attempting to point out the factors which have been found to be responsible for most of the failures to secure complete protection from late blight and rot by spraying with bordeaux mixture, the methods of preparing the mixture, which are commonly practiced, will first be considered. Unfortunately lack of ability to implicitly follow directions is a common fault of humanity and the maker of spray mixtures is no exception to the rule.

Bordeaux mixture as now recommended is the result of over 20 years of investigation and experimentation by some of the most careful workers in this country and in Europe and the formula recommended for potatoes conforms to the general consensus of opinion among these investigators. Anyone who departs from the formula, or who does not follow carefully the directions for preparing the spray should bear in mind that he alone is responsible if his bordeaux mixture fails to keep off the disease on account of being too dilute or, if unproperly prepared kills the foliage of the potato itself.

A rather surprising state of affairs was discovered when the methods of making of bordeaux mixture by potato growers in Aroostook county was investigated. The amount of copper sulphate used for each 50 gallons of spray varied from 2 1-2 to 12 or 15 pounds. Very commonly indeed, with a desire to do more efficient work, the amount of copper sulphate is increased to 8 and 10 pounds to 50 gallons of spray without any attempt made to more thoroughly cover the foliage by means of more nozzles per row or better adjustments of the nozzles on the sprayers. Fortunately the potato plant is much less susceptible to such strong sprays than fruit trees which would be ruined by such treatment.

It is a common practice, also, to use much more lime than copper sulphate—the maker reasoning that lime is inexpensive and a considerable excess may do good and certainly will do no harm. The function of the lime is to unite with the copper sulphate and convert it into temporarily insoluble compounds,

and it is doubtful if a large excess of lime adds to the fungicidal value of the mixture. Experiments have shown, however, that an excess of lime materially decreases the adhesive qualities of the mixture. "Those mixtures are best in adhesiveness, and in efficiency, in which the approximation of equal parts of copper sulphate and lime are maintained." *

One season's experiments conducted at this Station indicate that the prepared or hydrated lime will give equally good results as stone or lump lime used in making bordeaux mixture, judged by the appearance of the foliage and by the yield per acre at harvest time.**

Guess work is very frequently substituted for weights and measures, and the amount of lime and copper sulphate, or the stock solutions of these ingredients in a given amount of spray varied with the ability or judgment of the maker. One remarkable case was found where the individual prepared his stock solution of copper sulphate as follows: 50 pounds of the crystals were placed in a sack and suspended in a 50 gallon barrel of water in the usual way and allowed to dissolve. Then as fast as 5 or 10 gallons of this stock solution were taken out an equal amount of water was put in to replace it and this continued through the season. From time to time another 50 pounds of blue vitriol would be dissolved in the liquid. Thus it will be seen that except for the first lot of stock solution removed none used was of standard strength throughout the season. Bordeaux mixture prepared from such stock solutions cannot be expected to produce satisfactory results.

Properly prepared bordeaux mixture should contain 5 pounds each of copper sulphate and lime to 50 gallons of water, and the ingredients should be weighed and measured. The copper sulphate should be dissolved and the lime slaked in separate vessels. *Never pour concentrated solutions of lime and copper sulphate together.* The most adhesive and satisfactory mixture is prepared by diluting each strong solution with half of the water and then these two *dilute* solutions should be united quickly and thoroughly mixed at once. Full directions for preparing bordeaux mixture are contained in a circular entitled

* Crandall, C. S. Ill. Exp. Sta. Bul. 135, p. 218.

** Woods, C. D. Me. Expt. Sta. Bul. 98, p. 191-200 (1903).

"How to Fight Potato Enemies" which will be sent on application to the Maine Experiment Station.

Properly prepared and applied bordeaux mixture is a remarkably adhesive compound. If it once becomes dry on the foliage, which only requires a short time, it will be effective and resist excessive washings of rain for some time. The writer has preserved specimens of potato leaves taken at Foxcroft October 5, 1907, which are well coated with bordeaux mixture yet none had been applied to them for 38 days previously. At Orono during this period 6.66 inches of rain fell; 2.18 inches of this fell in 24 hours. These leaves had been thoroughly sprayed 6 times during the season. If bordeaux mixture does not show these adhesive qualities there is some fault with the method of preparation which should be remedied.

IMPROPER SPRAYING.

During a four-day trip over several of the larger potato growing towns in Northern Aroostook shortly after the blight had become well established, just two fields were seen which had been properly sprayed, yet some two or three thousand acres of potatoes were inspected. These conclusions as to spraying methods were arrived at by noting the condition of the fields, inspecting the spraying machinery and questioning the owners as to the methods of preparing the mixture, number of applications, time of application, etc.

The sprayers as a rule are deficient in that they do not carry enough nozzles and do not have sufficient adjustments. Bearing in mind the nature of the fungus which causes the disease, and the millions of spores which it produces, and bearing in mind also that each and every one of these spores is capable of infecting from one to several other leaves or tubers under right conditions, it will be seen that under some circumstances *a sprayer which does not cover every leaf with a thin film of spray may be practically useless* unless this defect can be remedied. The results obtained from such sprayers being so unsatisfactory that spraying often becomes discredited with the user and is abandoned. The majority of sprayers in use are equipped with single nozzles to the row which cannot be raised much above the tops of the plants, when the latter are full grown. Such a sprayer used at the time when late blight is

rife, and when the tops cover the ground, covers as a rule less than one-third of the foliage. All the remaining leaves being unprotected are killed with blight and millions of spores are washed down into the soil to infect the tubers. No matter how many times or how often such a sprayer is used on a field the resulting rot may be as great in seasons like those of 1907 and 1909, as if it had not been used at all.

EFFICIENT SPRAYERS AND SPRAYING.

One nozzle alone to a row should never be used on a potato sprayer when the tops grow as large as they do in Maine, except when the plants are small. When the plants are large, two or more nozzles should be used to the row, so arranged that the cones of spray will interfere with each other as little as possible, thus covering the widest possible area, or a strip at least 3 feet wide when the foliage covers the ground. There should be an up and down adjustment, sufficient so that the whole battery of nozzles may be raised as the plants grow taller. A side to side adjustment, to be varied with the distance between the rows is desirable also. Those sprayers which have additional nozzles which direct the spray sidewise into the tops from between the rows possess a distinct advantage in that they not only tend to more thoroughly cover the leaves but they also tend to reach the very ones which are first attacked by blight—the lower and more shaded leaves and those resting on the ground.

The finer the spray and the greater the pressure with which it is thrown the more effective will be the work. A very fine mist forcibly applied covers the leaf with a thin film which adheres, while even greater applications of spray applied in coarse drops may be less effective, first because it is not so evenly distributed and, secondly, because there is much more danger of the larger drops running together and dripping off the leaves. High pressure also tends to drive the mixture in among the leaves thus touching the lower leaves, and more effectually coating both sides of the leaves which is very important.

The Vermorel type of nozzle appears to be the most satisfactory and is the one most used by our growers. New brass caps should be applied to these each year, however, as the small

holes in these soon become worn and throw too coarse spray as a result. In use these nozzles should be carefully watched to see if each and every one is constantly working and throws a spray of maximum fineness. If not the machine should be stopped and the difficulty corrected. In purchasing a sprayer care should be taken to determine if the pump is powerful enough to throw a fine mist when the maximum number of nozzles necessary are in use. Sprayers equipped with hand pumps and designed to cover three or four rows at a time as fast as a horse can walk are not recommended. In practice the pressure usually maintained on these pumps is much too low to do effective work.

Unfortunately there has crept into our literature on potato spraying the statement, and the notion is quite firmly grounded in the minds of many of the potato growers and apparently in the minds of makers of potato spraying machinery as well that 50 gallons of spray per acre is a sufficient and proper amount to apply. A little thought will show how erroneous it is to conduct spraying operations on such a basis when the object is to cover the entire foliage. When the tops are small 50 gallons will usually do this, but it is absolutely impossible to do thorough work with this amount of spray when the plants are full grown. *Every leaf should be covered at each spraying, regardless of whether it takes 50, 100 or 150 gallons of bordeaux per acre.* In bad seasons like those under consideration it is advisable during the times when conditions are very threatening to go over the field twice at each spraying, in opposite directions on the row. However on account of danger of loss from drip, the second application should not be put on till the first is dry. This procedure is by all means recommended in place of using a stronger mixture, if more thorough work is desired.

WHEN TO SPRAY.

Very commonly men were found who did not spray during rainy weather as they considered it to be useless. This also is a mistaken notion. As has already been pointed out it is during rainy weather that spore production is the most rapid and infection is most sure to take place. Therefore, it is conceivable that one spraying during rainy weather may be more beneficial, even though it be washed off within a few hours as is supposed

to be the case by most people, than one applied during bright, clear weather. However, as previously stated, properly prepared bordeaux mixture is remarkably adhesive and will stand considerable washing if once dried on the foliage. Hence, *never omit to spray on account of rainy weather,* provided the rain stops long enough to apply the mixture and to allow it to dry on. There is often no excuse for the man who loses his crop by blight on account of rainy weather. If everything is in readiness it is a very exceptional season when the rain does not stop long enough to spray at least a part of a field at a time and to allow the spray to dry on after it is applied.

In 1909 many failures can be traced directly to too few sprayings and in every case investigated the spraying was discontinued much too early, considering the nature of the season. Large numbers of instances were found where the fields were sprayed but three times and cases where only two or even one application was made were by no means rare. Where these few applications were made, they were invariably made too early in the season, and while they doubtless did some good they were by no means distributed to the best advantage.

If one thoroughly understands the weather conditions which are likely to produce late blight it is possible to so distribute 3 or 4 thorough sprayings in such a manner as to give practically complete protection to the crop in ordinary seasons, but it would doubtless be impossible in such seasons as those of 1907 and 1909. If only 3 sprayings are made in this section it would usually be best to wait till late in July or the first of August before beginning. However, for the general grower who has not the benefit of long experience or the advice of a trained observer on these points it is unsafe to depend upon so few sprayings in a season. It has been the policy of this Station to recommend that spraying be begun when the tops are 6 to 8 inches high and repeated every 10 days (every week, if the weather is very cloudy or rainy)* until the last of August or the first of September, or later if necessary. In the light of the experience obtained during 1909 the only modification

* Cases might occur in exceptional seasons when the rains are very heavy and conditions very threatening where two or even three of the sprayings might be made at a less interval between.

of these recommendations suggested is to lay particular stress upon the clause "or later if necessary." In ordinary years the tops are killed by frost early in September and there is enough spray still adhering to them to furnish adequate protection till this takes place or the crop is dug. This year the tops were partially killed late in August but much of them were untouched till digging time. As a result of inefficient spraying, combined with excessive washing of rain, these were slowly dying of blight all through September and showering millions of spores onto the water-soaked soil, which resulted in an abnormal amount of tuber infection. Hence, *the tops should be protected by spray up to the day they are killed by frost or the crop is dug,* particularly in rainy seasons. As far as late blight is concerned some of the earlier sprayings might be dispensed with, but these early sprayings are necessary as protection against the early blight and ravages of the flea-beetle.

SPRAYING IS EFFECTIVE.

Spraying must be looked upon as a form of insurance but records covering a series of years show that it is the most profitable kind of insurance. Long continued experiments at the New York and Vermont Experiment Stations show that spraying is seldom conducted at a loss, after allowing for time and materials, and frequently it is the means of saving a large per cent of the crop. Records of yields of sprayed and unsprayed plots side by side covering a period of 17 years show an average increase of 113 bushels per acre or 68 per cent as a result of spraying. The greatest increase in any one year was 224 bushels and the least was 32 bushels per acre.* The writer upon Commissioner Gilman's farm in Foxcroft in 1907 secured an increase over unsprayed plots of 231 bushels of sound tubers per acre from 6 double sprayings, 162 bushels from 6 single sprayings, and 186 bushels from 3 double sprayings plus one single spraying. He also secured from 6 double sprayings on the John Watson farm at Houlton 420 bushels of sound tubers on a measured acre with no decay following in storage, while fields in this vicinity either unsprayed or less thoroughly protected were showing from 25 to 75 per cent of

* Jones, L. R. and Giddings, N. J., Vt. Exp. Sta. Rep. 20, p. 339.(1908).

rot. Other well sprayed fields nearby were equally well protected. The plots at Foxcroft which had 6 double sprayings gave 0.6 per cent of rot while those at Houlton showed 9.1 per cent. There is no doubt that equally good results might have been obtained on nearly every field in Aroostook county in 1909 if they had all received as thorough spraying. In fact a few cases, particularly in the vicinity of Houlton, were found where spraying had been thoroughly done. Here the foliage was fully protected through the season and little or no rot was found on digging. Though dug early, two of these lots showed no rot and one other a slight amount after about three weeks of abnormally warm weather in storage.

These demonstrations that thorough spraying with bordeaux mixture will give entire protection from the ravages of late blight are by no means new in Maine. Nine years ago Director Woods of this Station secured with four sprayings at Houlton increased yields valued at over $40.00 per acre at the current price of potatoes at an estimated expense of $2.50 per acre.*

DECAY IN STORAGE 1909.

The season of 1909 in Aroostook county demonstrated again on a large scale what has previously been shown to be true experimentally, namely; that where potatoes are blighting it is unsafe to dig and store the crop for at least ten days after the tops are killed by frost, and even a longer delay will do no harm.**

The crop on many fields where the blight had secured more or less of a foothold was dug early in September. In many cases these tubers were practically all sound when dug but the blighting leaves were producing spores abundantly which were showered on the potatoes. These potatoes on account of the excessive rains came out of the soil wet and in most cases were not allowed to dry off before being picked up and placed in barrels, thus furnishing ideal conditions for infection by late

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* Woods, C. D. Me. Expt. Stat. Bulletin 112 pp. 2-5 (1905).

** Jones, L. R. and Morse, W. J. Repts. Vt. Exp. Sta. 15, pp. 219-223 (1902); 16, pp. 161-163 (1903).

See also Proceedings Society for Promotion of Agricultural Science (1904).

Woods, C. D., Me. Expt. Stat. Bulletin 112, pp. 2-5 1905).

blight.* They were then placed in storage or shipped to market. The weather following was quite warm and humid. As a result of this infection, much of the stock which went to market was a total loss, and in some cases the results in storage were nearly equally bad. If a repetition of this disaster is to be avoided, it will be necessary to first keep the blight off by thorough spraying such as has been previously recommended in this article. If blight does gain a foothold to any extent, if possible do not disturb the crop till at least ten days after the tops are killed by frost, two weeks will be better. There will be some rot in any event if the tops show much blight, but the net result of sound tubers in the end will be largely in favor of late digging.

OTHER CAUSES OF DECAY.

In closing this discussion it should be remarked that there are present in the State two other potato diseases which cause decay of the tuber and which cannot be prevented by any amount of spraying. There is no evidence, however, up to the present time, that either of these diseases have been a contributing factor to the epidemics of tuber decay which have occurred in Maine. One of these is the Fusarium dry rot which differs from the late blight rot in that it nearly always begins at the stem end of the tuber in the form of a brownish or blackened ring a short distance below the surface, and the later stages of the rot are more or less different also. The other tuber decay is a soft bacterial rot caused by the same organism which produces the Blackleg disease of the stem. Potatoes affected by the late blight fungus usually develop a soft, stinking rot in storage under moist, warm conditions, but the writer believes that most of this decay is due to a secondary infection by ordinary saprophytic soil bacteria which otherwise could not attack the healthy tubers themselves.

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* This is not a mere supposition for the writer has assisted in performing an experiment where these conditions were producted artificially with identical results. See Jones, L. R. and Morse, W. J. Vt. Exp. Sta. Rept. 18, pp. 284-287 (1905).

Director Woods also cites a similar experience as occurring in 1902. See Me. Expt. Sta. Bull. 112, p. 1 (1905).

SUMMARY.

Adverse weather conditions were responsible for severe epidemics of late blight and rot of the potato in Maine, particularly in Aroostook county, during the seasons of 1907 and 1909. (P. 165.)

Blight is caused by a parasitic fungus which spreads through the leaves, killing the tissues as it goes. Each blighting leaf produces thousands of minute fungus spores each capable of infecting another leaf, or a potato tuber. (P. 166.)

Bordeaux mixture forms a protective film on the healthy leaves, kills the spores which fall thereon, and also kills those produced on the diseased leaves at the time of application. (P. 166.)

Much, if not all, of the disease comes originally from planting diseased seed tubers. Rain, dew, wind, insects, etc., are the chief agencies in disseminating the spores. (P. 173.)

Late blight is most destructive in rainy or cloudy weather. Hot, dry, sunshiny weather is fatal to the blight spores, and outbreaks of the disease never occur under these conditions. (P. 173.)

Much of the bordeaux mixture used is carelessly and improperly prepared. Only standard bordeaux mixture containing 5 pounds of copper sulphate and 5 pounds of lime to 50 gallons of water should be used. The most adhesive mixture is made by diluting the copper sulphate and lime solutions each with half of the water and then quickly and thoroughly mixing. *The ingredients should be weighed and measured and the proportions should not be varied.* (P. 174.)

The sprayers carry too few nozzles per row and do not have sufficient adjustments of nozzles. Pumps should be powerful and nozzles in such condition that the spray will be delivered forcibly and in a fine mist. (P. 176.)

Fifty gallons per acre is not enough spray to use when the plants cover the ground. Every leaf should be coated at each application. When conditions are very threatening, go over the rows a second time in opposite directions, after the first application becomes dry. (P. 178.)

Never omit spraying on account of rainy weather, this is the one time when spraying is most needed. (P. 178.)

Under Maine conditions it is necessary to begin when the tops are 6-8 inches high and spray every week or ten days till the tops are killed by frost or the crop harvested. If weather conditions are favorable, sprayings may be less frequent early in the season, but not through August and September. If the conditions are very threatening spraying at less intervals is advised. Much loss from blight and rot results from too few sprayings and stopping too early in the season. (P. 179.)

Thorough spraying under very adverse weather conditions has been found effective both in Maine and elsewhere. Thoroughly sprayed fields in Aroostook county in 1909 showed very little loss from either blight or rot. (P. 180.)

Much storage rot in 1909 resulted from infection at digging time. If blight has not been kept off the foliage wait at least ten days, if possible, after the tops are killed by frost before harvesting. (P. 181.)

Two other tuber decays occur but these were not contributing factors in the two epidemics. (P. 182.)